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(54) [Title of the Invention] CONDUCTIVE ANTIREFLECTION FILM

(57) [Abstract]

[Purpose] To obtain a conductive antireflection film which can prevent surface reflection of outside light as well as suppress internal reflection to a low value so as to make it possible to prevent generation of a ghost phenomenon even when the film is formed on the surface of a flat cathode-ray tube by forming first and second layers one of which is a light absorption layer, forming third and fourth layers one of which is a light absorption layer, and further forming fifth and sixth layers of dielectric layers having different predetermined refractive indices from each other.

[Structure] A conductive antireflection film includes a structure in which a layer

including titanium nitride (TiN_x) as a first layer, a layer including silicon nitride (SiN_x) as a second layer, a layer including silicon oxide (SiO_2) as a third layer, a layer including nickel oxide (NiO_x) as a fourth layer, a layer including titanium oxide (TiO_2) as a fifth layer, and a layer including silicon oxide (SiO_2) as a sixth layer are sequentially stacked over a glass substrate G. The thickness of the first layer serving as a light absorption layer is set to 5 to 25 nm whereas the thickness of the fourth layer serving as a light absorption layer is set to 5 to 50 nm.

[Scope of Claims]

[Claim 1] A conductive antireflection film, which is an anti-light reflection film including first to sixth layers sequentially stacked over a glass substrate, wherein one of the first and second layers is a TiNx layer serving as a light absorption layer and the other is an SiNx layer, one of the third and fourth layers is a layer made from oxide or nitride of transition metal serving as a light absorption layer and the other is a layer made from oxide or nitride of Si, the fifth layer is a dielectric layer with a refractive index n of 1.9 to 2.7, and the sixth layer is a dielectric layer with a refractive index n of 1.35 to 1.7.

[Claim 2] A conductive antireflection film, which is an anti-light reflection film including first to sixth layers sequentially stacked over a glass substrate, wherein one of the first and second layers is a TiNx layer serving as a light absorption layer and the other is an SiNx layer, one of the third and fourth layers is a layer made from oxide or nitride of transition metal serving as a light absorption layer and the other is a layer made from oxide or nitride of Si, the fifth layer is a TiO_2 layer, and the sixth layer is an SiO_2 layer.

[Claim 3] The conductive antireflection film according to claim 1, wherein the first layer is a TiNx layer, the second layer is an SiNx layer, the third layer is an SiO_2 layer, and the fourth layer is an NiOx layer.

[Claim 4] The conductive antireflection film according to claim 1, wherein the first layer is a TiNx layer, the second layer is an SiNx layer, the third layer is an NiOx layer, and the fourth layer is an SiO_2 layer.

[Claim 5] The conductive antireflection film according to claim 1, wherein the

first layer is an SiNx layer, the second layer is a TiNx layer, the third layer is an SiNx layer, and the fourth layer is a TiNx layer.

[Claim 6] The conductive antireflection film according to claim 1, wherein the first layer is a TiNx layer, the second layer is an SiNx layer, the third layer is an SiO_2 layer, and the fourth layer is a Cr_2O_3 layer.

[Claim 7] The conductive antireflection film according to any one of claim 1 through claim 6, wherein the thickness of the light absorption layer positioned in the first or second layer is set to 5 to 25 nm.

[Claim 8] The conductive antireflection film according to any one of claim 1 through claim 7, wherein the thickness of the light absorption layer positioned in the third or fourth layer is set to 5 to 60 nm.

[Claim 9] The conductive antireflection film according to claim 1, wherein the light absorption layer has light transmittance of 45 to 65% with respect to light with a wavelength of 550 nm and the internal reflectance of the whole film is set to 10% or less.

[Detailed Description of the Invention]

[0001]

[Industrial Field of the Invention] The present invention relates to a conductive antireflection film having an electromagnetic shielding effect formed on a surface of a cathode-ray tube or the like, and in particular relates to a conductive antireflection film using a light absorption layer.

[0002]

[Conventional Art] Conventionally, an antireflection film made from a transparent multilayer dielectric film is formed on a glass substrate to protect reflection of a surface of a cathode-ray tube and shield electromagnetic wave. However, this type of the antireflection film requires, for example, several tens of layers in order to widen the low reflective wavelength range, which results in increase of production costs considerably. In recent years, an antireflection film using a light absorption layer made from titanium oxynitride and the like has been used (Japanese Patent Publication No. Hei 10-87348).

[0003] A cathode-ray tube having an almost-flat surface has been attracting attention recently. A conductive antireflection film formed on a surface of such a cathode-ray tube has been developed rapidly. In such a flat cathode-ray tube, the thicknesses of a center portion and a peripheral portion are greatly different from each other in order to enhance mechanical strength. The light transmittance of a glass material is extremely high to equalize the light intensity from a fluorescent surface. However, the total light transmittance of the surface of the cathode-ray tube is required to be the same value as that of the conventional one, and therefore, the light transmittance of the above conductive antireflection film must be reduced in accordance with increase in light transmittance of a glass material.

[0004] In the conventional art disclosed in the above mentioned patent publication, a titanium oxynitride film and a film mainly containing silica each having a predetermined thickness are used as an antireflection film, and the light transmittance thereof can be reduced by up to 50% (for example, 75% in the conventional antireflection film) while maintaining the low value of reflectance with respect to outside light (hereinafter, referred to as surface reflectance).

[0005]

[Problem to be Solved by the Invention] However, in a case of using a light absorption layer as an antireflection film, the surface reflectance is different from the reflectance with respect to light from an inner fluorescent surface (hereinafter, referred to as an internal reflectance) unlike in the case of using a dielectric layer.

[0006] For example, in the above patent publication, the internal reflectance is high as about 16 to 20%, and therefore, as shown in FIG. 15, in light generated by electron beam entering in a fluorescent layer 13, light T1, which passes through a glass material (glass substrate) 12 and an antireflection film 11, and light T2, which internally reflects on an interface between the glass material 12 and the antireflection film 11 and then internally reflects on the fluorescent layer 13 so as to pass through the antireflection film 11, are generated. This results in generation of a ghost phenomenon.

[0007] The present invention is made in view of the above described circumstances and it is an object of the invention to provide a conductive antireflection film which can

prevent surface reflection of outside light sufficiently as well as suppress internal reflection to a low value so as to make it possible to prevent generation of a ghost phenomenon even when the film is formed on the surface of a flat cathode-ray tube.

[0008]

[Means for Solving the Problem] A conductive antireflection film of the present invention is an anti-light reflection film including first to sixth layers stacked over a glass substrate, in which one of the first and second layers is a TiNx layer serving as a light absorption layer and the other is an SiNx layer, one of the third and fourth layers is a layer made from oxide or nitride of transition metal serving as a light absorption layer and the other is a layer made from oxide or nitride of Si, the fifth layer is a dielectric layer with the refractive index n of 1.9 to 2.7, and the sixth layer is a dielectric layer with the refractive index n of 1.35 to 1.7.

[0009] Further, it is preferable that the fifth layer be a TiO_2 layer and the sixth layer be an SiO_2 layer. The following four layer structures are given as preferable specific modes. The first specific layer structure is that the first layer is a TiNx layer, the second layer is an SiNx layer, the third layer is an SiO_2 layer, and the fourth layer is an NiOx layer.

[0010] The second specific layer structure is that the first layer is a TiNx layer, the second layer is an SiNx layer, the third layer is an NiOx layer, and the fourth layer is an SiO_2 layer.

[0011] The third specific layer structure is that the first layer is an SiNx layer, the second layer is a TiNx layer, the third layer is an SiNx layer, and the fourth layer is a TiNx layer.

[0012] The fourth specific layer structure is that the first layer is a TiNx layer, the second layer is an SiNx layer, the third layer is an SiO_2 layer, and the fourth layer is a Cr_2O_3 layer.

[0013] It is preferable that the thickness of a light absorption layer positioned in the first or second layer be set to 5 to 25 nm.

[0014] It is preferable that the thickness of a light absorption layer positioned in the third or fourth layer be set to 5 to 60 nm.

[0015] It is preferable that the light absorption layer have the light transmittance of 45 to 65% with respect to light with the wavelength of 550 nm and the internal reflectance of the whole film be set to 10% or less.

[0016] Each layer described above contains each above-mentioned material as a main material and may also contain other impurity substances.

[0017]

[Embodiment Mode of the Invention] A conductive antireflection film of the embodiment mode of the present invention will hereinafter be described with reference to the drawings.

[0018] A conductive antireflection film of the embodiment mode of the present invention is formed on a surface of a cathode-ray tube to reduce surface reflection of outside light on the surface of the cathode-ray tube. The conductive antireflection film is an anti-light reflection film having a structure in which first to sixth layers are sequentially stacked on a glass substrate. One of the first and second layers is a TiNx layer serving as a light absorption layer and the other is an SiNx layer. One of the third and fourth layers is a layer made from oxide or nitride of transition metal serving as a light absorption layer and the other is a layer made from oxide or nitride of Si. The fifth layer is a TiO_2 layer. The sixth layer is an SiO_2 layer.

[0019] That is, in the conductive antireflection film of this embodiment mode, one of the first and second layers is the TiNx layer serving as the light absorption layer , one of the third and fourth layers is the layer made from oxide or nitride of transition metal serving as the light absorption layer, and the fifth layer is the TiO_2 layer. This makes it possible to set light transmittance of the whole film to be about 50% and reduce reflectance (internal reflectance) with respect to light from an inner fluorescent layer to be 10% or less while keeping an intrinsic surface antireflection effect preferably. The light absorption layer is set to have 45 to 65% of light transmittance with respect to light with a wavelength of 550 nm.

[0020] Further, it is desirable that the thickness of the TiNx layer serving as the light absorption layer, which is provided in one of the first and second layers, be set to 5 to 25 nm and the thickness of the layer made form oxide or nitride of transition metal

serving as the light absorption layer, which is provided in one of the third and fourth layers, be set to 5 to several tens of nm though it is differed depending on its material.

[0021] When such light absorption layers have the thicknesses of less than the above mentioned lower limits, the low reflective wavelength region is widen. However, the surface reflectance is gradually increased. On the other hand, when the thicknesses exceed the above mentioned upper limits, the wavelength region where the surface reflectance is low is narrowed. In a case where the thicknesses are further increased, the surface reflectance is gradually increased.

[0022] Further, when the thicknesses thereof exceed the above limits, the internal reflectance is also increased gradually.

[0023] Therefore, the thicknesses of the light absorption layers are desirably set to be within the above ranges where both surface reflectance and internal reflectance can be set to extremely low values.

[0024] As the transition metal, titanium (Ti), chromium (Cr), nickel (Ni), zirconium (Zr), hafnium (Hf), vanadium (V), niobium (Nb), tantalum (Ta), and the like is used.

[0025] Further, the SiO_2 layer of the sixth layer, which is a top layer, serves as a protection layer.

[0026] The method of forming the light absorption layers is not particularly limited and the CVD method, the sputtering method, and the like can be employed. As the sputtering method, the RF sputtering method or the direct-current reactive sputtering method can be given. In particular, it is desirable that the direct-current reactive sputtering method be used and a mixed gas including nitrogen, a rare gas, and an oxidized gas be used as a sputtering gas.

[0027] A conductive antireflection film of the present invention will hereinafter be described in detail in the following embodiments using specific numerical values.

[0028]

[Embodiments] <Embodiment 1> A conductive antireflection film of Embodiment 1 has a structure in which a layer including titanium nitride (TiN_x) as a first layer, a layer including silicon nitride (SiN_x) as a second layer, a layer including silicon oxide (SiO_2) as a third layer, a layer including nickel oxide (NiO_x) as a fourth layer, a layer including

titanium oxide (TiO_2) as a fifth layer, and a layer including silicon oxide (SiO_2) as a sixth layer are sequentially stacked over a glass substrate G as shown in FIG. 1. Shaded regions indicate light absorption layers respectively (which are the same in FIGS. 2 to 4).

[0029] The optical constant (refractive index (n) and extinction coefficient (k) in a case where the complex refractive index is shown by n ± ik) and the geometric thickness (nm) of each layer of Embodiment 1 are shown in Table 1.

[0030] Further, the surface reflectance, the internal reflectance, and the film transmittance with respect to light with a wavelength of 550 nm of the conductive antireflection film of Embodiment 1 are shown in the right portion of Table 1.

[0031]

[Table 1]

Embodiment 1

layer	substance	optical constant (550 nm)		film thickness	surface reflectance	internal reflectance	film transmittance
		n	k				
6	SiO_2	1.51	0	94.00	0.20%	2.37%	56.04%
5	TiO_2	2.61	0	14.38			
4	NiO_x	2.2	0.6	14.00			
3	SiO_2	2.51	0	15.40			
2	SiN_x	2.09	0	35.00			
1	TiN_x	2.1	1.38	10.00			
substrate	glass	1.52	0	-			

[0032] In addition, the visible-light-region reflection characteristics (a horizontal axis indicates the wavelength (nm) of incident light whereas a longitudinal axis indicates the optical reflectance (%)) of the conductive antireflection film of Embodiment 1 are shown in FIG. 5 and FIG. 6. The measurement in this case is carried out by measuring the spectroscopic reflectance when measurement light enters in the conductive antireflection film with an incident angle of 5° (5° reflection measurement; which is the

same in the following embodiments 2 to 4 and comparative example).

[0033] <Embodiment 2> As shown in FIG. 2, a conductive antireflection film of Embodiment 2 has a structure in which a layer including titanium nitride (TiN_x) as a first layer, a layer including silicon nitride (SiN_x) as a second layer, a layer including nickel oxide (NiO_x) as a third layer, a layer including silicon oxide (SiO_2) as a fourth layer, a layer including titanium oxide (TiO_2) as a fifth layer, and a layer including silicon oxide (SiO_2) as a sixth layer are sequentially stacked over a glass substrate G.

[0034] The optical constant (refractive index (n) and extinction coefficient (k) in a case where the complex refractive index is shown by n ± ik) and the geometric thickness (nm) of each layer of Embodiment 2 are shown in Table 2.

[0035] Further, the surface reflectance, the internal reflectance, and the film transmittance with respect to light with a wavelength of 550 nm of the conductive antireflection film of Embodiment 2 are shown in the right portion of Table 2.

[0036]

[Table 2]

Embodiment 2

layer	substance	optical constant (550 nm)		film thickness	surface reflectance	internal reflectance	film transmittance
		n	k				
6	SiO_2	1.51	0	95.00			
5	TiO_2	2.61	0	20.47			
4	SiO_2	1.51	0	8.61			
3	NiO_x	2.2	0.6	14.00	0.11%	3.69%	59.19%
2	SiN_x	2.09	0	40.00			
1	TiN_x	2.1	1.38	9.00			
substrate	glass	1.52	0	-			

[0037] In addition, the visible-light-region reflection characteristics (a horizontal axis indicates wavelength (nm) of incident light whereas a longitudinal axis indicates optical reflectance (%)) of the conductive antireflection film of Embodiment 2 are shown in

FIG. 7 and FIG. 8.

[0038] <Embodiment 3> As shown in FIG. 3, a conductive antireflection film of Embodiment 3 has a structure in which a layer including silicon nitride (SiN_x) as a first layer, a layer including titanium nitride (TiN_x) as a second layer, a layer including silicon nitride (SiN_x) as a third layer, a layer including titanium nitride (TiN_x) as a fourth layer, a layer including titanium oxide (TiO_2) as a fifth layer, and a layer including silicon oxide (SiO_2) as a sixth layer are sequentially stacked over a glass substrate G.

[0039] The optical constant (refractive index (n) and extinction coefficient (k) in a case where the complex refractive index is shown by n ± ik) and the geometric thickness (nm) of each layer of Embodiment 3 are shown in Table 3.

[0040] Further, the surface reflectance, the internal reflectance, and the film transmittance with respect to light with a wavelength of 550 nm of the conductive antireflection film of Embodiment 3 are shown in the right portion of Table 3.

[0041]

[Table 3]

Embodiment 3

layer	substance	optical constant (550 nm)		film thickness	surface reflectance	internal reflectance	film transmittance
		n	k				
6	SiO_2	1.51	0	79.94	0.04%	0.51%	47.03%
5	TiO_2	2.61	0	11.67			
4	TiN_x	2.1	1.38	13			
3	SiN_x	2.09	0	51.49			
2	TiN_x	2.1	1.38	10.9			
1	SiN_x	2.09	0	17.78			
substrate	glass	1.52	0	-			

[0042] In addition, the visible-light-region reflection characteristics (a horizontal axis indicates wavelength (nm) of incident light whereas a longitudinal axis indicates optical reflectance (%)) of the conductive antireflection film of Embodiment 3 are shown in

FIG. 9 and FIG. 10.

[0043] <Embodiment 4> As shown in FIG. 4, a conductive antireflection film of Embodiment 4 has a structure in which a layer including titanium nitride (TiN_x) as a first layer, a layer including silicon nitride (SiN_x) as a second layer, a layer including silicon oxide (SiO_2) as a third layer, a layer including chromium oxide (Cr_2O_3) as a fourth layer, a layer including titanium oxide (TiO_2) as a fifth layer, and a layer including silicon oxide (SiO_2) as a sixth layer are sequentially stacked over a glass substrate G.

[0044] The optical constant (refractive index (n) and extinction coefficient (k) in a case where the complex refractive index is shown by n ± ik) and the geometric thickness (nm) of each layer of Embodiment 4 are shown in Table 4.

[0045] Further, the surface reflectance, the internal reflectance, and the film transmittance with respect to light with a wavelength of 550 nm of the conductive antireflection film of Embodiment 4 are shown in the right portion of Table 4.

[0046]

[Table 4]

Embodiment 4

layer	substance	optical constant (550 nm)		film thickness	surface reflectance	internal reflectance	film transmittance
		n	k				
6	SiO_2	1.51	0	91.84	0.33%	3.94%	54.99%
5	TiO_2	2.46	0	38.06			
4	Cr_2O_3	2.3	0.45	24.94			
3	SiO_2	1.51	0	13.58			
2	SiN_x	2.39	0.07	14.32			
1	TiN_x	2	0.97	10.00			
substrate	glass	1.52	0	-			

[0047] In addition, the visible-light-region reflection characteristics (a horizontal axis indicates wavelength (nm) of incident light whereas a longitudinal axis indicates optical

reflectance (%)) of the conductive antireflection film of Embodiment 4 are shown in FIG. 11 and FIG. 12.

[0048] <Comparative example> The above-mentioned conductive antireflection film disclosed in the Japanese Patent Publication No. Hei 10-87348 was used as a comparative example.

[0049] The conductive antireflection film of the comparative example has a structure in which a layer including titanium nitride (TiN_x) as a first layer, a layer including silicon nitride (SiN_x) as a second layer, and a layer including silicon oxide (SiO_2) as a third layer are sequentially stacked over a glass substrate. The geometric thickness of the first layer was set to 18 nm, the geometric thickness of the second layer was set to 9 nm, and the geometric thickness of the third layer was set to 72 nm.

[0050] The surface reflectance, the internal reflectance, and the film transmittance with respect to light with a wavelength of 550 nm of the film in this comparative example were 0.53%, 16.62%, and 55.48%, respectively.

[0051] In addition, the visible-light-region reflection characteristics (a horizontal axis indicates wavelength (nm) of incident light whereas a longitudinal axis indicates optical reflectance (%)) of the conductive antireflection film of the comparative example are shown in FIG. 13 and FIG. 14.

[0052] The surface reflectance, the internal reflectance, and the film transmittance with respect to light with a wavelength of 550 nm of Embodiments 1 to 4 and the comparative example are complied in Table 5.

[0053]

[Table 5]

	spectroscopic characteristic (%) in the wavelength of 550 nm		
	surface reflectance	internal reflectance	transmittance
for conventional CRT	0.27	8.8	78.9
for flat CRT (comparative example)	0.02	16.0	52.9
Embodiment 1	0.20	2.37	56.0

Embodiment 2	0.11	3.69	59.2
Embodiment 3	0.04	0.51	47.0
Embodiment 4	0.33	3.94	55.0

[0054] Table 5 and FIGS. 5 to 14 apparently show that in the conductive antireflection film of each of the embodiments, the film transmittance can be set to the optimum value for a flat cathode-ray tube and the internal reflectance can be drastically reduced while maintaining the low value of the surface reflectance.

[0055] A conductive antireflection film of the present invention is not limited to the films described in the above embodiments and the thickness and the like of each layer can be changed appropriately.

[0056] For example, in Embodiment 1, the geometric thicknesses of the first layer and the fourth layer can be changed in the range of 5 to 25 nm and the range of 5 to 50 nm, respectively. Further, in Embodiment 2, the geometric thicknesses of the first layer and the third layer can be changed in the range of 5 to 25 nm and the range of 5 to 50 nm, respectively. In Embodiment 3, the geometric thicknesses of the second layer and the fourth layer can be changed in the range of 5 to 25 nm and the range of 5 to 25 nm, respectively. Furthermore, in Embodiment 4, the geometric thicknesses of the first layer and the fourth layer can be changed in the range of 5 to 25 nm and the range of 5 to 60 nm, respectively.

[0057] Although the layer including titanium oxide (TiO_2) is formed as the fifth layer and the layer including silicon oxide (SiO_2) is formed as the sixth layer in each of the above embodiments, the fifth layer can be formed using a layer made from other dielectric material with the refractive index n of 1.9 to 2.7 and the sixth layer can be formed using a layer made from other dielectric material with the refractive index n of 1.35 to 1.7.

[0058]

[Effect of the Invention] As described above, a conductive antireflection film of the present invention includes an anti-light reflection film having six layers formed over a glass substrate in which one of a first layer and a second layer is a TiN_x layer serving as

a light absorption layer and the other is an SiN_x layer, one of a third layer and a fourth layer is a layer made from oxide or nitride of transition metal serving as a light absorption layer and the other is a layer made from oxide or nitride of Si, a fifth layer is a dielectric layer with the refractive index n of 1.9 to 2.7, and a sixth layer is a dielectric layer with the refractive index n of 1.35 to 1.7. That is, one of the first and second layers, which is closest to the glass substrate, is a light absorption layer, and one of the third layer and the fourth layer positioned thereover is another light absorption layer so as to form a two stacked light absorption layers. In addition, the fifth layer positioned thereover is the dielectric layer with the above refractive index. This structure can reduce the internal reflectance drastically while keeping the low value of the surface reflectance under the condition where the film transmittance is set to the predetermined value.

[0059] This makes it possible to prevent generation of ghost images, which is a serious problem in the conventional art, while satisfying the conditions of a conductive antireflection film formed over a flat cathode-ray tube.

[Brief Description of the Drawings]

[FIG. 1] FIG. 1 is a schematic view showing a layer structure of a conductive antireflection film according to Embodiment 1 of the present invention.

[FIG. 2] FIG. 2 is a schematic view showing a layer structure of a conductive antireflection film according to Embodiment 2 of the present invention.

[FIG. 3] FIG. 3 is a schematic view showing a layer structure of a conductive antireflection film according to Embodiment 3 of the present invention.

[FIG. 4] FIG. 4 is a schematic view showing a layer structure of a conductive antireflection film according to Embodiment 4 of the present invention.

[FIG. 5] FIG. 5 is a graph showing surface reflectance characteristics of the conductive antireflection film according to Embodiment 1 of the invention.

[FIG. 6] FIG. 6 is a graph showing internal reflectance characteristics of the conductive antireflection film according to Embodiment 1 of the invention.

[FIG. 7] FIG. 7 is a graph showing surface reflectance characteristics of the conductive antireflection film according to Embodiment 2 of the invention.

[FIG. 8] FIG. 8 is a graph showing internal reflectance characteristics of the conductive antireflection film according to Embodiment 2 of the invention.

[FIG. 9] FIG. 9 is a graph showing surface reflectance characteristics of the conductive antireflection film according to Embodiment 3 of the invention.

[FIG. 10] FIG. 10 is a graph showing internal reflectance characteristics of the conductive antireflection film according to Embodiment 3 of the invention.

[FIG. 11] FIG. 11 is a graph showing surface reflectance characteristics of the conductive antireflection film according to Embodiment 4 of the invention.

[FIG. 12] FIG. 12 is a graph showing internal reflectance characteristics of the conductive antireflection film according to Embodiment 4 of the invention.

[FIG. 13] FIG. 13 is a graph showing surface reflectance characteristics of the conductive antireflection film according to the comparative example.

[FIG. 14] FIG. 14 is a graph showing internal reflectance characteristics of the conductive antireflection film according to the comparative example.

[FIG. 15] FIG. 15 is a diagram for explaining a problem of the conventional art.

[Description of Reference Numerals]

G, 12: glass substrate, 11: antireflection film, 13: fluorescent layer

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